Initial teacher education: exploring student teachers' experiences in a physics learning study

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Abstract

A learning Study was conducted among physics student teachers in their placement in a secondary school in England. The particularity of this learning study is that trainees researched collaboratively the critical features of the object of learning, but plan and enact the whole cycle of teaching alone. Peer observation was sacrificed in order to allocate more teaching time in their placement. The aim of this research was to explore the student teachers experiences during the learning study. Two trainees were observed during their lessons and interviewed at the end of the learning study. Participants expressed having difficulties when handling variation theory, designing and enacting patterns of variation, and also exploring the pupils' conceptions of the phenomenon. It seems that the learning study approach helps student teachers to start shifting their understanding of teaching and learning, from focusing on the agent of teaching to the act of teaching, and to the object of learning. Participants also expressed the central role of collaboratively group work among trainees.

Keywords: Learning study, Variation theory, Phenomenography, Initial Teacher Education, Student teacher

Introduction

Some of the challenges of initial teacher training courses are to change student teachers' beliefs about teaching and learning, and to make them aware of their own conceptions and how those influence their (and their pupils') performance. Wood (2000) found three levels of conception about teaching among student teachers. The first focuses on the teachers themselves as agents of transmitting knowledge and understanding pupils as simple receptors of information. In the second, teachers are more interested in pupils' responses in order to change their thinking and learning. The third focuses on the pupils' change of conceptions of the object of learning so they become more complex. Similarly, Schulman (1986) argued that for a teacher it is not enough to know the content teach (CK) but also the strategies and best approaches to teach this particular content, or what he called pedagogical content knowledge (PCK).

Phenomenography (Marton and Booth, 1997) understands learning as the change in conception from a simple to a more complex explanation of any phenomenon. According to it, the "conscious awareness" (Marton and Booth, 1997: 51) of any critical feature is

the difference of one conception of the phenomenon and another. Then, learning occurs when pupils are able to discern more critical features and link them together in order to explain the object of learning in a different way (Marton and Tsui, 2004). The features of an object of learning can be discerned when pupils experience differences in the features whilst other non-critical features remain invariant. In the words of Ko (2014: 274), "the theory argues that discernment is necessary for learning and variation makes discernment possible".

Variation theory (VT) was developed from the phenomenography approach which is concerned with "different ways of experiencing phenomena (Marton and Booth, 1997: 111)". This view understands that there is more than a right or wrong answer, but a range of different understandings of the same phenomenon, from simple to more complex ones. Its aim, then, is to qualitatively explain the different views of an object, how people experience and understand the same object.

This paper reports on research which explores student teachers' experiences handling variation theory through their participation in a learning study. Learning studies (Marton and Tsui, 2004) attempt to improve the Japanese approach of Lesson studies. A lesson study is a collaborative approach to plan, teach and review a lesson in a cycle of teaching which includes several teachers (Stigler and Hiebert, 1999). Teachers choose a particular object of learning (what is to be learnt), design a lesson and one of them enacts the plan while the other teachers observe it. Then, the plan is reviewed in the light of the observations and taught again by another teacher to another group of pupils. Learning studies differ from Lesson studies by taking a theoretical framework of learning (phenomenography and variation theory) for their inquiry and design, whereas Lesson studies base their approach to the teachers' practitioner knowledge.

Research (Nilsson, 2014; Davies and Dunnill, 2008) found that being part of a learning study could lead student teachers to a shifting in understanding teaching from weak to a more powerful conception of teaching. Ko (2011: 58) also reported that "Instead of focusing on their own performance as teachers, the student teachers became more attentive to the pupils' learning difficulties and were able to consider teaching from their pupils' point of view".

Handling Variation theory

According to Ko (2011: 51) there are three distinctive types of variation; variation on how pupils understand the object of learning (T1); variation in teachers' understanding the object of learning (T2); and using variation patterns to improve pupils' understanding of the object of learning (T3). A formal Learning study begins with the exploration of pupils' conceptions of the object of learning itself (T1). Inquiring about how pupils see the object of learning allows teachers to design a lesson in terms of the pupils' prior knowledge and assist them to restructure their conceptions. Next, teachers explore their own conceptions in terms of variation theory, discerning the critical aspects to describe the object of learning (T2). Finally, teachers plan collaboratively a lesson in terms of VT (T3). This means to use the pupils' prior conception and teachers' findings in order to create a rationale of activities which will lead pupils to change their conception of the object of learning. These activities are designed in terms of VT: varying the critical aspects to make pupils discern them and their effects on the object of learning.

In order to discern the critical aspects, pupils need to experience different patterns of variation of those aspects (Pang and Marton, 2003), varying the values of them while keeping the values of other aspects constant. To maximise pupils' understanding of the object of learning, it is required to bring about different kinds of discernment (Marton and Tsui, 2004): contrast, separation, generalisation and fusion. When it is possible to experience different values of a feature in the same object (black vs white; big vs small) it is referred as contrast. Separation occurs when the feature can be separated from the object through contrasting with other features. For example, big house and small house, the value big is separated of the object and the aspect "size" opens up. When using variation in an object while keeping constant the aspect we want to highlight (big house, big car, big bed) this aspect is separated from other (colour, shape, etc.) and it is said the be generalised. Fusion is the process of linking the different features and aspects to fully understand the object of learning, the relationships among the features and to the whole at the same time.

Even though discernment through variation is essential, it does not guarantee success, the fact that the variation is explicit and observable by pupils does not mean that they experience it. This is aligned with Pang and Lo (2012) who argue that what it is important is what pupils really experience, and not the designed pattern of variation. Other research

(Ko, 2014; Chik and Lo, 2004) support this claim finding that differences in teacher enactment can make a great difference bringing awareness and improving learning.

Ko (2011) analysing several pieces of research found that two conditions were critical for a learning study to succeed. First, student teachers should complete a cycle of teaching with close guidance by their tutor: discussing, planning, teaching, observing, and planning again to change and to improve the lesson. And second, it was found crucial to create in-depth and quality dialogue and collaboration among student teachers. Not only having plenty of opportunities to discuss and avoid quick agreements, but also to share a theoretical framework in order to focus the inquiry of the lesson design. Davies and Dunnill (2008) found that the discussion and collaborative planning could be very challenging, especially for those still understanding teaching as imparting knowledge (Wood, 2000). Cajkler *et al.* (2013) found that for some student teachers assessing the pupils' learning and understanding of the phenomenon could be challenging, having difficulties to focus the scope of their inquiry and making the pupils new conceptions surface.

Research design

Our purpose was to explore the student teachers' experiences in a learning study and using variation theory as a theoretical framework. This study was qualitative and exploratory.

An initial teacher education in a physics programme from a university in West-Midlands (UK) was approached and agreed collaboration. This course was selected because it uses Learning Study as one of its teaching and learning approaches. The programme consisted in 13 trainees and their mentor. Following discussion of the process, two student teachers volunteered for this study, denoted by the pseudonyms Aaron and Ben. Both trainees were male physics graduates between 20 and 25 years old.

The tutor determined *interference of waves* as the first object of learning, and a second object of learning, *coherence* as a particular wave interference. "Wave interference is the phenomenon that occurs when two waves meet while traveling along the same medium. The interference of waves causes the medium to take on a shape that results from the net effect of the two individual waves upon the particles of the medium (Henderson, 2015). Two waves are coherent if they have a constant phase difference. The student teachers

discussed its critical features and collaboratively designed the learning outcome circle and a table of patterns of variation. A learning outcome circle is an adaptation of concept maps in the light of phenomenography. Instead of illustrating the "correct" way of understanding the phenomenon, the learning outcome circle highlights the different attributes of the phenomenon and it allows any particular conception by just linking the attributes in different ways (Davies and Dunnill, 2008). However, each trainee individually designed their own lesson plan and their activities using VT. All student teachers taught their lessons at the same time to a group of between 4 and 6 pupils. Right after they had enacted the lesson, they had a meeting with other student teachers to discuss how they had experienced the lesson, successes and challenges. After this meeting, they taught again the same object of learning with other pupils. The cycle of teaching took place in a sixth form, evaluated as Good by Ofsted, in the same region of the university. The pupils were between 16 and 18 years old.

Data were collected from student teachers through their lesson plans, learning outcome circles and teaching materials, through observation field notes taken during their lessons and meeting, and through in-depth semi-structured interviews conducted at the end of the cycle of teaching. Audio recordings of the interviews were transcribed. The same researcher observed both participants in their lessons and the meetings between lessons, and carried out the interview. The whole process of collecting data took about 3 weeks. Two consecutive Fridays were the lessons and meetings took place and another week for interviewing the participants.

Data from the interviews and meeting field notes were inductively analysed by cutting chunks related to the same phenomenon and organised on a pool of meaning. Then this pool of meaning was analysed for themes (Denscombe, 2003). Teaching materials and field notes were deductively analysed on the light of the phenomenographic approach and VT in order to describe the use of VT in practice.

Findings

Student teachers' understanding of teaching and learning

From a phenomenographic point of view, pupils have different starting conceptions of a given phenomenon, and learning is to change this initial conception to a more complex one (Marton and Booth, 1997). Aaron said:

> I wanted them all to have the same level of knowledge before I can teach them the more advanced stuff, about interference

Aaron's conception of teaching and learning is still focused on the agent of teaching (Wood, 2000). He believed that all pupils must have the same conception in order to carry on with the lesson. However the same student teacher also said:

> I think what I will take from this experience is try to focus my lesson planning on how the pupils will learn rather than how I can fill the lesson with relevant activities

This perspective of teaching and learning is more sophisticated because, at this point, he focuses on the act of teaching (Wood, 2000). As he (*ibid*) also found, conceptions of teaching and learning are not that clearly separated. It seems that conceptions coexist at the same time as suggested by phenomenography (Marton and Booth, 1997). Ben also explained that the use of VT helped him to focus on the content:

> The point is you have clear things you want them to be understood in terms of what you want them to discern […] because I started with the conceptions in the first place to create the outcome circle, I think its greatest strength is it gives you a tool for breaking down quite complex things into very defined and clear concepts or critical aspects

Although, student teachers can still understand teaching and learning as a transmission of knowledge, it seems that for Aaron and Ben the use of VT has encouraged them to start thinking in terms of the object of learning, and focusing in the content and the aspects to be discerned as starting point of their planning. This is aligned with Runesson (2006) and Ko (2011) who argued that one of the most significant features of the VT is its clear focus on the object of learning. This allows teachers to think about the critical aspects instead of beginning with 'the tasks they will use to fill the lesson'.

Handling VT in practice

Four dimensions were found related to handling VT in practice: challenges exploring pupils' conceptions of the phenomenon, the lack of focus on the phenomenon, challenges enacting patterns of variation, and VT to promote PCK.

One of the characteristics of Learning Studies is the need to explore pupils' conceptions of the phenomenon. Before student teachers taught the lesson, they had sessions where they could explore pupils' conceptions. About this, Ben said:

> To be honest exactly what they were thinking wasn't that clear for me, so it didn't help me that much to plan the interference lesson

Ben recalled having difficulties when exploring pupils' understandings. The issue was how to make explicit pupils' knowledge about interference. Aaron also explained:

> I said to them what do they know about interference and some of them had heard the word before but I don't think any of them knew in the context of waves

In both cases, it seems that trainees did not focus their inquiry on the exploration of the critical aspects pupils were already aware of. Some of their questions were about the knowledge of some concepts, the characteristics of a wave (such as amplitude or frequency) instead of how any of these concepts affected the object of learning. It seems, that when exploring pupils' conceptions it is needed a clearer focus on the phenomenon itself. For teachers still understanding teaching and learning as a cumulative transmission of knowledge, the idea of exploring conceptions of what they are going to teach does not make sense, but to assure that all pupils have the "required" previous knowledge. So, it might be also a good idea for unexperienced teachers to have a prepared activity guided by their mentor in order to explore pupils' conceptions with more guaranties of success.

In our study, both participants had difficulties organising the different kinds of discernment and with focusing on the phenomenon. For example, Ben used two robes to try to make pupils discern path difference. Then he used paper-based activities for amplitude, and a digital oscilloscope for phase. All of these activities were designed to understand the phenomenon of wave interference, although it seemed that pupils experienced three different phenomena. The importance of the focus on the same phenomenon when varying features seems not to be highlighted enough in Learning Study's literature. Moreover, in the first activity with robes the phenomenon was made visible with pulses (not waves) which should come as a generalisation after the critical aspects are discerned (Ko, 2014). The patterns of variation to discern the critical aspects were designed as traditional book activities, instead of looking at the same phenomenon all the time and changing values of one aspect while keeping the other constant. One

possible reason for this is that student teachers still think in terms of activities and not in terms of the object of learning. Ben recognised that:

> The picture…I thought it was quite cool analogy.

Ben used this activity with the picture because he tough it was "cool" even though the interference in question was very different from the one of the object of learning, in appearance and in concept. This lack of focus on the phenomenon was even clearer when participants were dealing with c*oherence*. Ben said:

> I was varying this things in order them [pupils] to discern what make a coherent wave and incoherent wave, but they [pupils] couldn't do that because I was trying to get to use that to also figure out what coherence was in the first place.

A similar reflection was made by Aaron:

> In both cases before they could understand coherence they needed to understand what phase was and how phase can vary, and then how difference in frequency causes a non-constant phase difference and how these two factors affect whether waves are coherent or not.

In either of these cases pupils experienced *coherence* as a phenomenon. Pupils experienced different features independently with the hope that eventually they would make sense of it. However it seems that this was a problem. It seems that all the features should be in place when using VT in order to experience the phenomenon as a whole. Experience the same phenomenon all the time while discerning its critical features.

Another challenge that both trainees recognised was with the enactment of patterns of variation. Ben explained that in the activity with the oscilloscope pupils had too loose guidance and pupils experienced different patterns which confused them:

> They [pupils] didn't handle very well…I needed to be like well, if you do this value and this value…. It's the variety that shows what I want to show, to make the point I want to make clear, whereas giving them as an open thing they could see other patterns I didn't want them to see.

When using a digital oscilloscope pupils changed several aspects at the same time. Pupils experienced different mixed patters which confused them. This agrees with orthodox

Learning Study literature which argues that one feature must be varied while others remain constant.

In terms of the knowledge required for teaching, Aaron said:

> I probably would take more care in breaking down my definitions of each one and getting more confident about my subject knowledge and then on top of that I would probably have more examples in the middle.

With this reference to his own subject knowledge, Aaron assumes that what makes possible for a teacher to teach effectively it is his own content knowledge (Shulman, 1986), something expectable for a teacher still mainly thinking in terms of transmitting knowledge. However, he also pointed out the way the content is better handled in order to maximise pupils' learning, or in terms of PCK (*ibid*). Similarly, Ben commented:

> I think generally with VT is better when you make it very explicit to the students the idea behind what you're doing in terms of we are systematically changing something to discern something

Aligned with Nilsson (2014) it seems that the use of VT helps student teachers to focus on the best approach to teach and learn a particular content which in turn seems to develops teachers' PCK.

Format of the learning study: advantages and challenges

One of the characteristics of this particular learning study was its format. Student teachers discussed together the object of learning and the aspects to discern. However, every trainee then planned and enacted their own lesson at the same time, so they did not observe how other colleagues taught it. The student teachers' mentor commented the tension between the formal learning study design and the interest of providing teaching experience to the trainees. This is why it was decided to prioritise teaching time instead of peer observation. The question is then if collaborative planning of the activities using VT and the mutual observation are critical aspects.

Ben recalled having problems enacting some patterns of variation:

> I can't really articulate why I couldn't put that into a variation pattern but I couldn't, possibly because I was trying to do it by myself, maybe if I had people helping.

Aaron explained how challenging it was to design specific activities for each aspect to discern:

> Finding resources that match the patterns of variation, so for example, it's hard to build a resource of two waves where the shapes of wave are different and they are interfering and everything else is the same. I think it takes a lot effort to find that sort of stuff

Chik and Lo (2004) found that even having the same object of learning and the same selected critical aspects, the way teachers enact the lesson brings different levels of awareness among pupils, and consequently different learning. Runesson (2006) in an experiment about drawing and movement found that it is crucial to know what dimensions of the phenomenon must be opened, but also how they are opened, their sequence and simultaneity. For student teachers, it seems that it is not only the discussion about the critical aspects of the object of learning what it is critical, but also the design of the different patterns of variation to be enacted. Wider collaboration also in the design of experiences using VT seems an aspect that could improve the lessons and the pupils' awareness of the critical features which could lead to more complex understanding of the phenomenon.

Both trainees explained their positive experience collaborating with other student teachers in terms of how the group work improved their own learning. Aaron and Ben said respectively:

> The planning process, I really enjoyed it because as a group we were able to come up with ideas that I would not though as individual and we were focusing our attention on subject knowledge which was something that I thought is miss out when planning using the traditional methods

> The value of it [collaboration] was its depth. I think that was the process of you present something and someone else criticizes it. It was very much a refinement process and I think that would be quite difficult to do as well by yourself

However, some tensions with these views were identified in the meetings where trainees had to explain their experiences in the lesson and to give feedback to their colleagues. Trainees had about a one hour gap between lessons in order to discuss their experiences with one object of learning. During the same time, trainees had to eat, use the toilets or simply have a break, which left the reflection and discussion into the background. Some comments were made by student teachers about their general feelings and how they thought the lesson went, but without a clear focus. Ko (2011) found that collaboration must be of quality and in-depth as a critical aspect of as learning study to succeed. It seems that arranging these meetings the same day trainees teach the lesson bring some

difficulties to surpass. Availability of time was linked to this challenge not only in initial teacher education but also in future placements. Ben said:

> Time consumption [is a disadvantage], and also I think in the future you might not have quite as much opportunity to, in work if you plan to do that, you probably don't have as much time to develop a plan lesson and probably you're not gonna have that discussion as much with colleagues

In this learning study peer observation had to be sacrificed in order to allocate more teaching time for trainees. This fact let the other enacted lessons hidden to the trainees and the possibilities for learning and improvement that it brings. In his lesson, Ben designed a pattern of variation to make pupils discern the aspect of path difference in the wave interference object of learning. In order to interfere, two waves must be at the same place at the same time, then they can superimpose and create a resulting wave, otherwise they continue independently. Aaron, however, did not even mention this aspect to his pupils. It seems that peer observation could have its importance. If peer observation would have been implemented, aspects like path difference could had been identified and solved by all student teachers.

Conclusion

There is plenty of literature confirming the benefits of Learning study for both pupils and teachers (Ling and Marton, 2011; Pang, 2010; Pang and Marton, 2005; Holmqvist, 2011; Kullberg, 2010; Nilsson, 2014). However, little is been said about the issues and challenges that this approach carries, especially in Initial Teacher Education.

First, shifting student teachers' understanding of learning and teaching is complex and not clearly defined. Even though in some moments trainees can think in terms of content, in some other they still think in terms of method or as transmitting knowledge. It seems that all three Wood's (2000) views of learning and teaching coexist together. This is aligned with Davies and Dunnill (2008) who found resistance on this change, especially for those who still focus on the agent of teaching. However, it seems that VT could help student teachers to begin to think in terms of the object of learning and focusing on the content instead of in the methods.

Second, the lack of focus on the phenomenon seems to be an important issue. When exploring the pupils' conceptions of the phenomenon, student teachers tend to explore

knowledge not related to the object of learning, but what they think is a requirement to build on. It seems that closer guidance was required. Furthermore, the activities to make pupils discern the critical features of the object of learning must be tightly focused on the same phenomenon because "[in any phenomenon] we do not experience the parts as themselves, but we experience the wholes of which the parts are part (Marton and Booth, 1997: 100)." If the parts pupils are experiencing are not related to the same phenomenon they could experience another whole phenomenon and not necessarily relate the parts to the whole.

Finally, in this study is been also found the critical importance of collaboration among student teachers. Furthermore, it seems that both in-depth collaboration and peer observation are critical aspects of the learning study approach (Ko, 2011). It is not only essential the collaboration discerning the critical aspects of the object of learning, but also while planning the patterns of variation, its sequence and simultaneity, and the mutual observation.

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